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(54) **FUSING DEVICE FOR AN ELECTROPHOTOGRAPHIC IMAGE FORMING APPARATUS**

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(30) **Foreign Application Priority Data**

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(52) **U.S. Cl.** **399/330**; 219/216; 432/60
(58) **Field of Search** 399/307, 330, 399/334; 219/216, 388, 469; 432/60; 492/46

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,426,495 A * 6/1995 Sawamura et al. 399/331
5,805,766 A * 9/1998 Wang 392/343
5,945,020 A * 8/1999 Kuroda et al. 219/543
5,987,295 A * 11/1999 Matsuo et al. 399/330
6,571,080 B2 * 5/2003 Lee et al. 399/330
6,580,896 B2 * 6/2003 Lee 399/330
6,628,917 B2 * 9/2003 Lee 399/330
6,665,515 B2 * 12/2003 Lee 399/330

FOREIGN PATENT DOCUMENTS

JP 10268686 A * 10/1998 .... G03G/15/20
JP 11065340 A * 3/1999 .... G03G/15/20
JP 11184290 A * 7/1999 .... G03G/15/20

* cited by examiner

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(57) **ABSTRACT**

A fusing device for an electrophotographic image forming apparatus. The fusing device includes a heat pipe, both ends of which are sealed and in which a predetermined amount of a working fluid is contained, a cylindrical roller which surrounds the heat pipe, and a heating element which is installed between the cylindrical roller and the heat pipe. The working fluid is supercooled at room temperature, and crystallizing and producing heat when acted on by a mechanical force, and at least one mechanical unit applies a mechanical force to the heat pipe and crystallizes the supercooled working fluid.

10 Claims, 5 Drawing Sheets

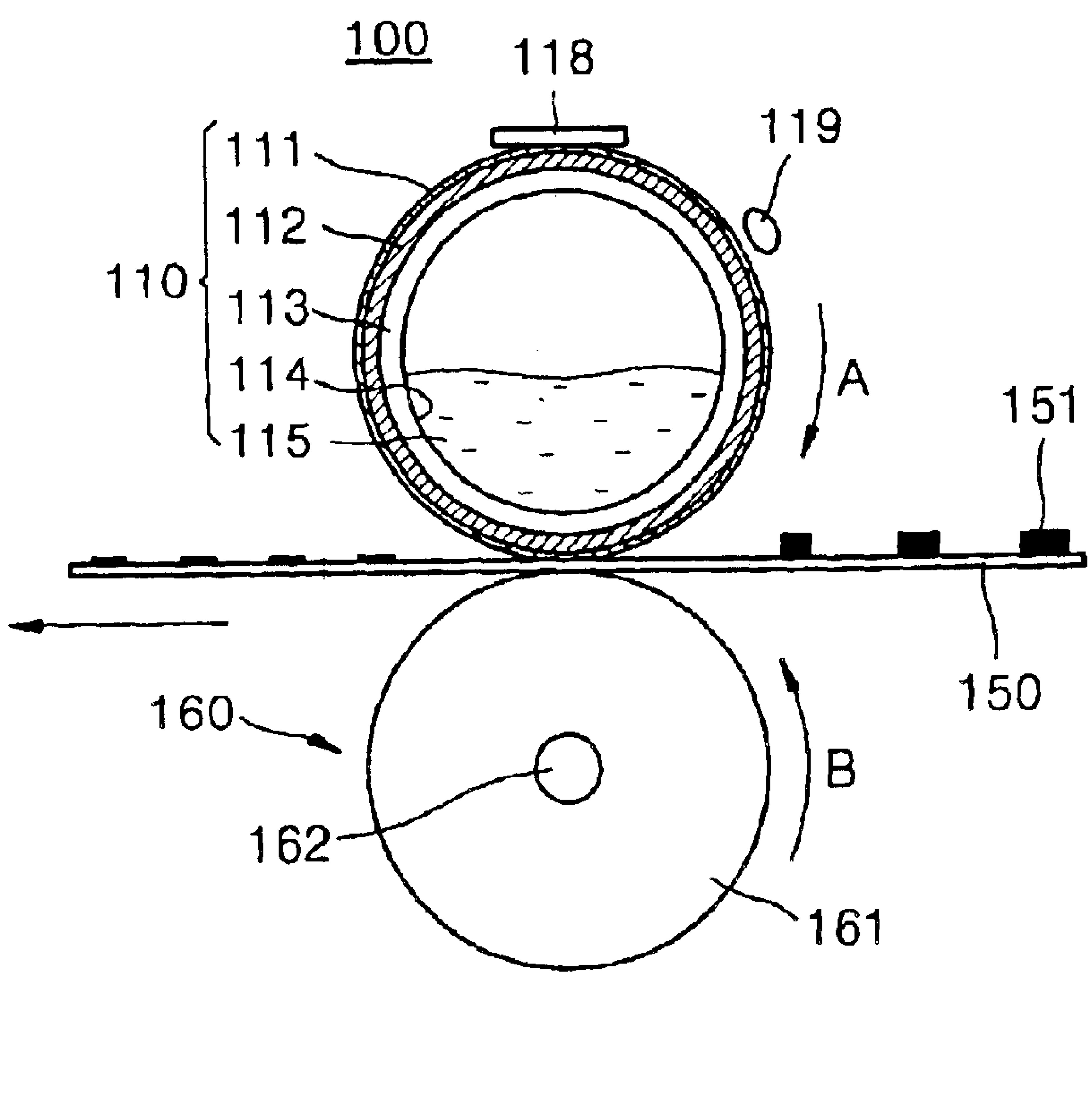


FIG. 1 (PRIOR ART)

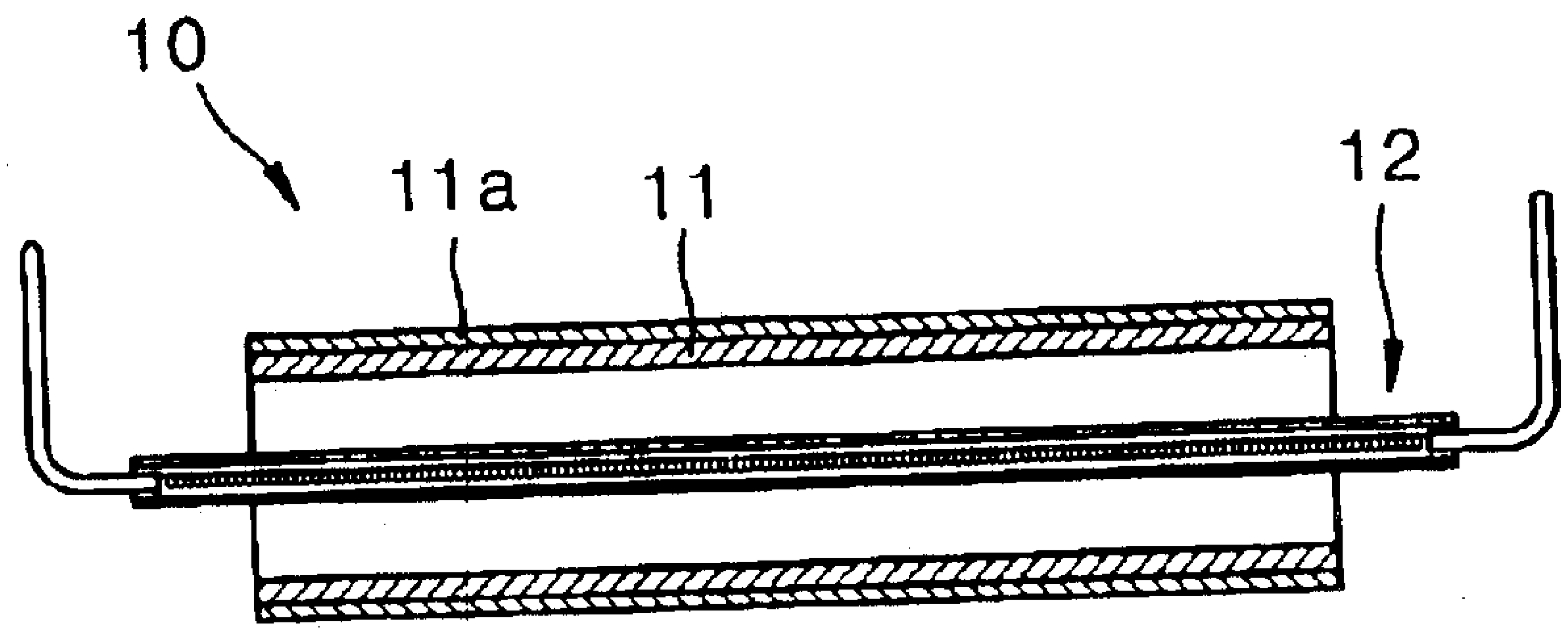


FIG. 2 (PRIOR ART)

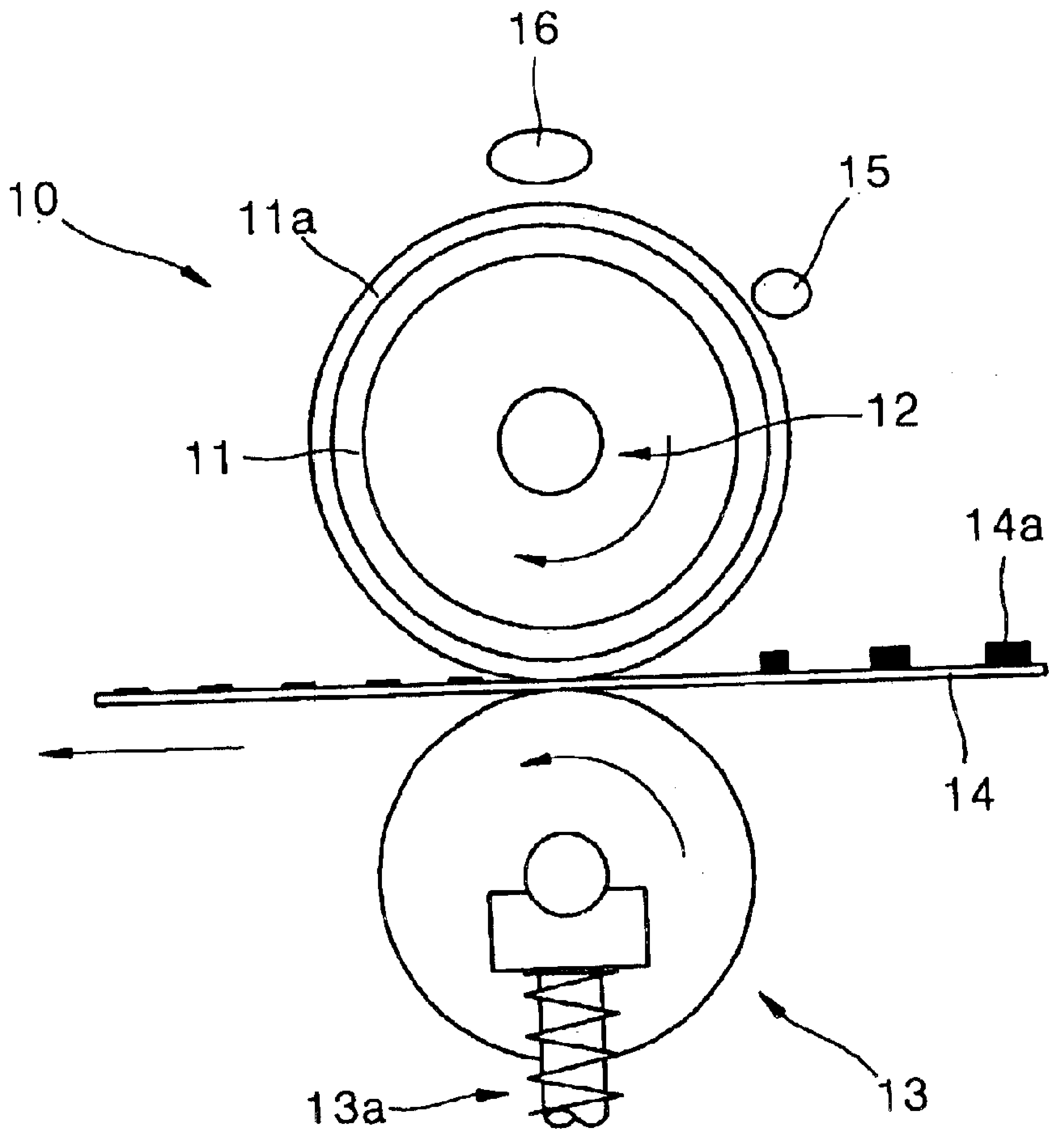


FIG. 3

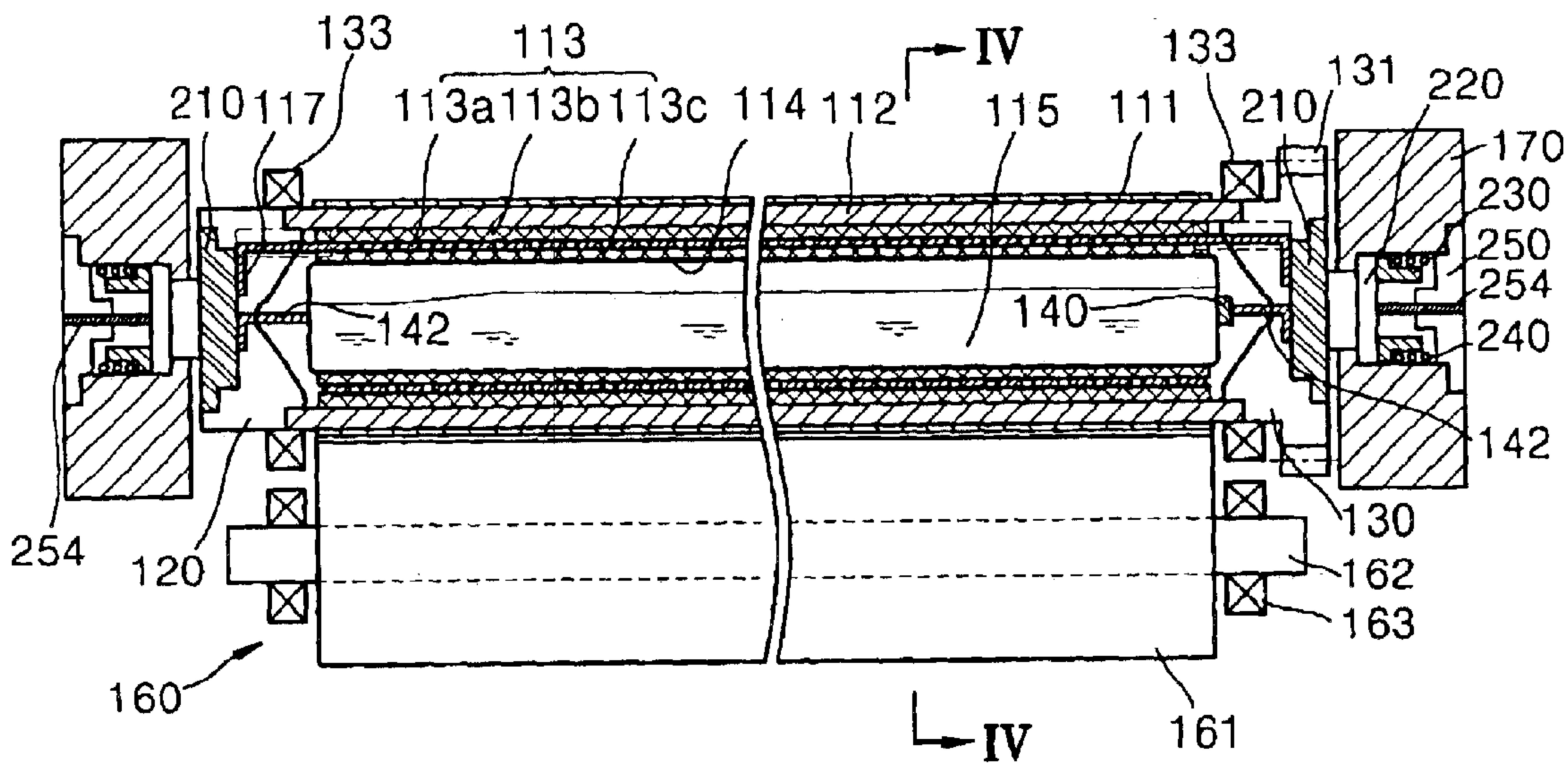

133
113
113a 113b 113c
114
112
IV
210 117
115
111
133
131
210
220
170
230
250
254
240
142
140
142
254
120
130
162
163
160
161
IV

FIG. 4

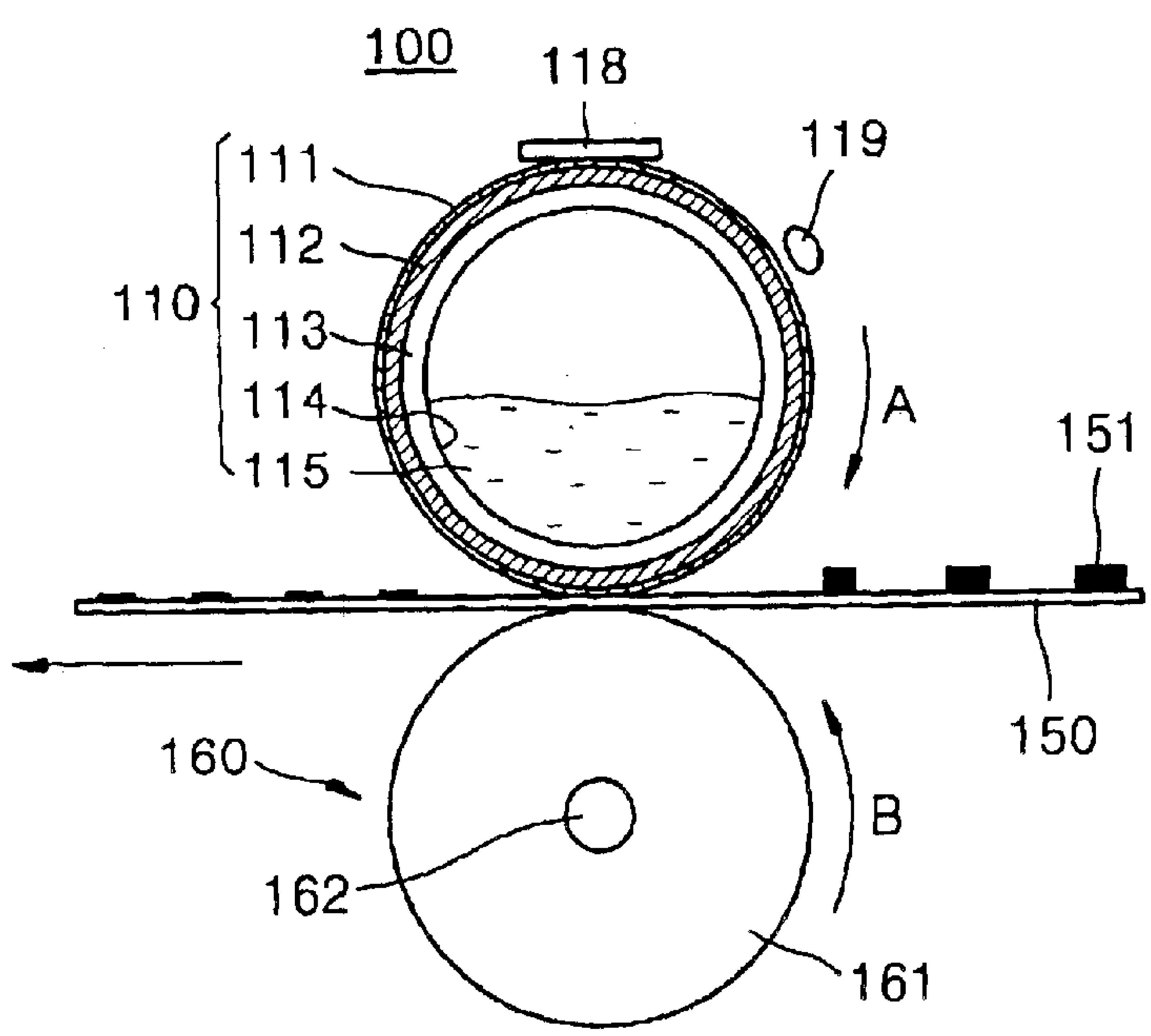

100
118
119
111
112
110
113
114
115
A
151
150
160
B
162
161

FIG. 5A

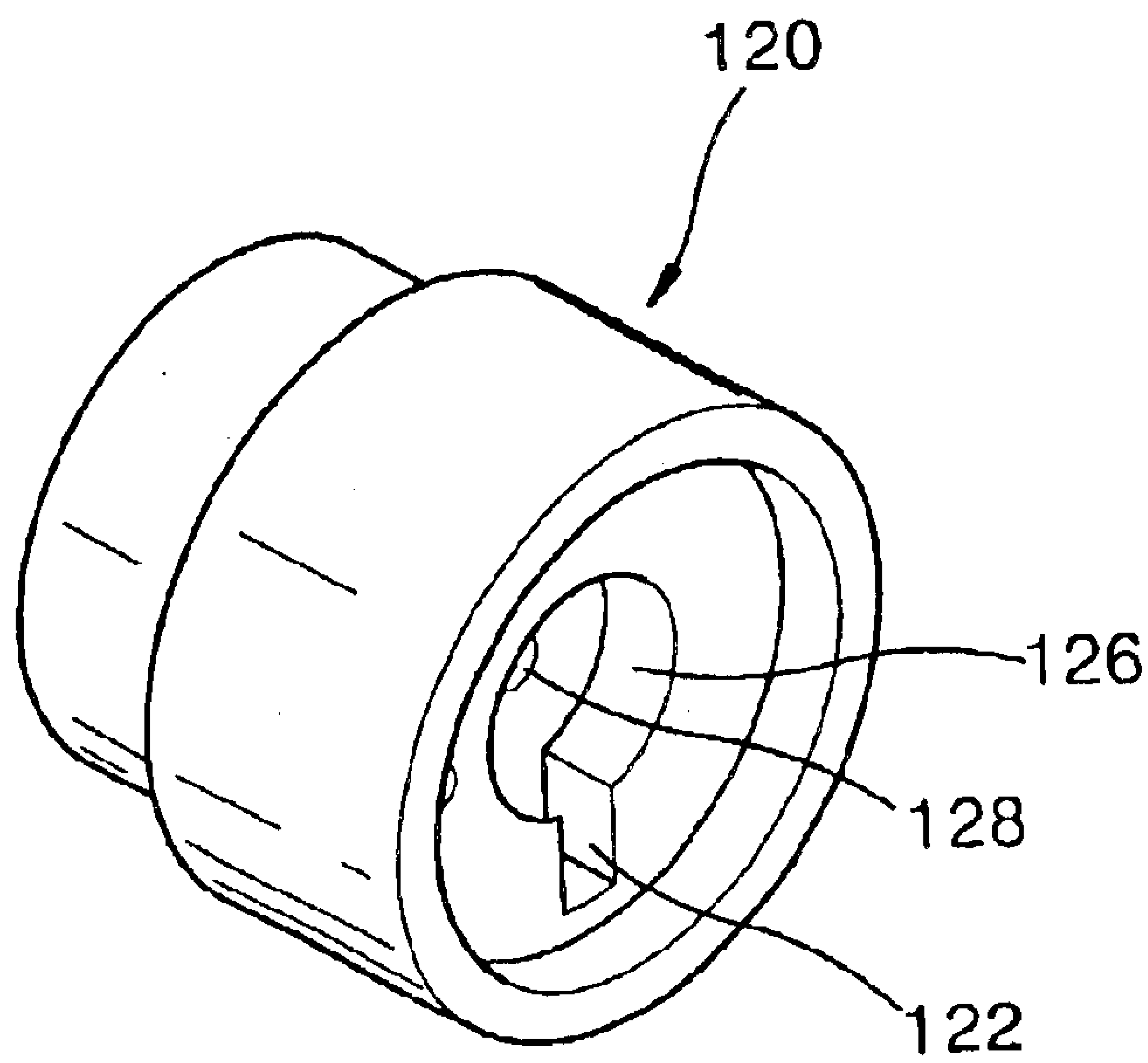


FIG. 5B

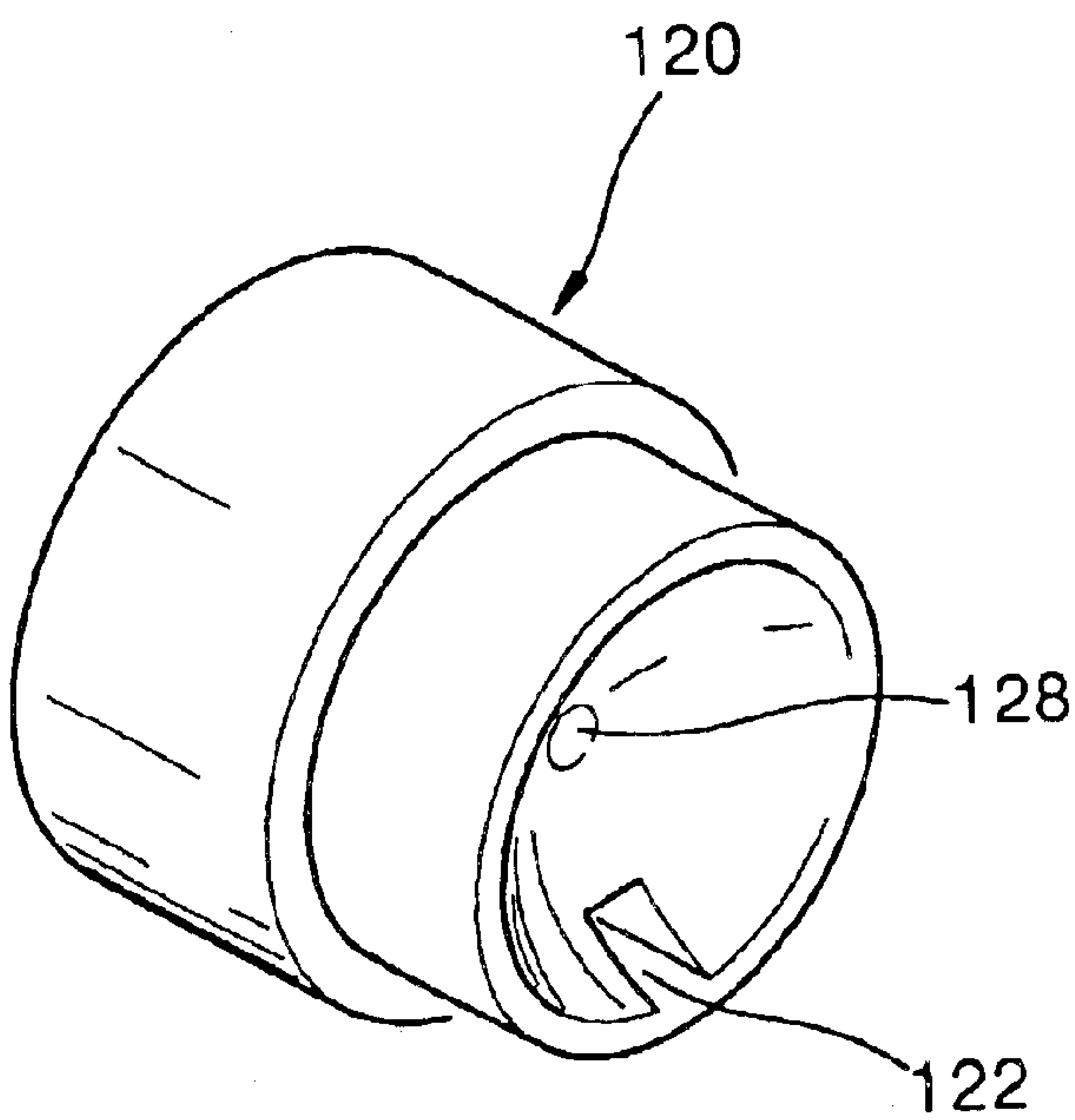


FIG. 6A

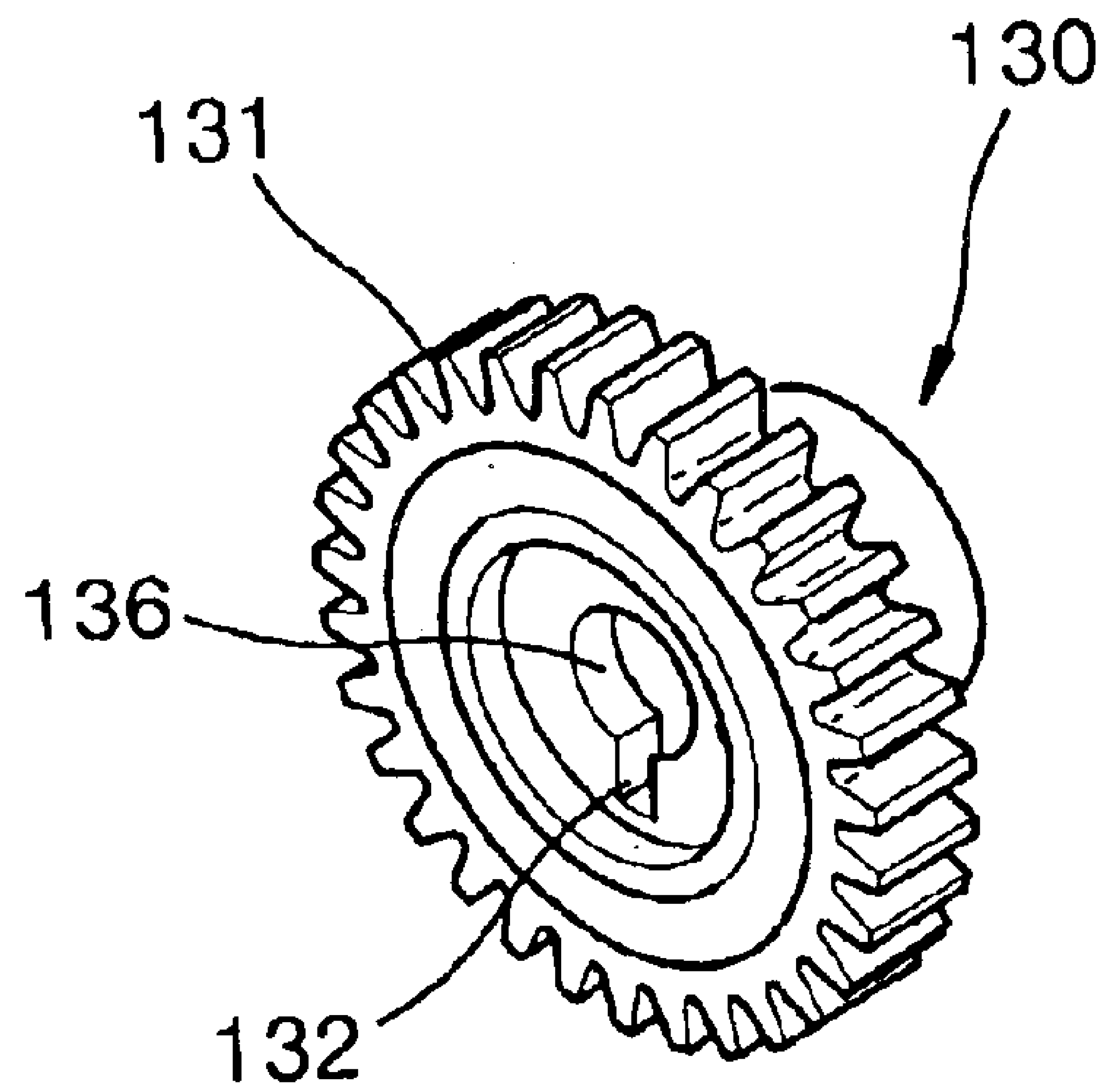


FIG. 6B

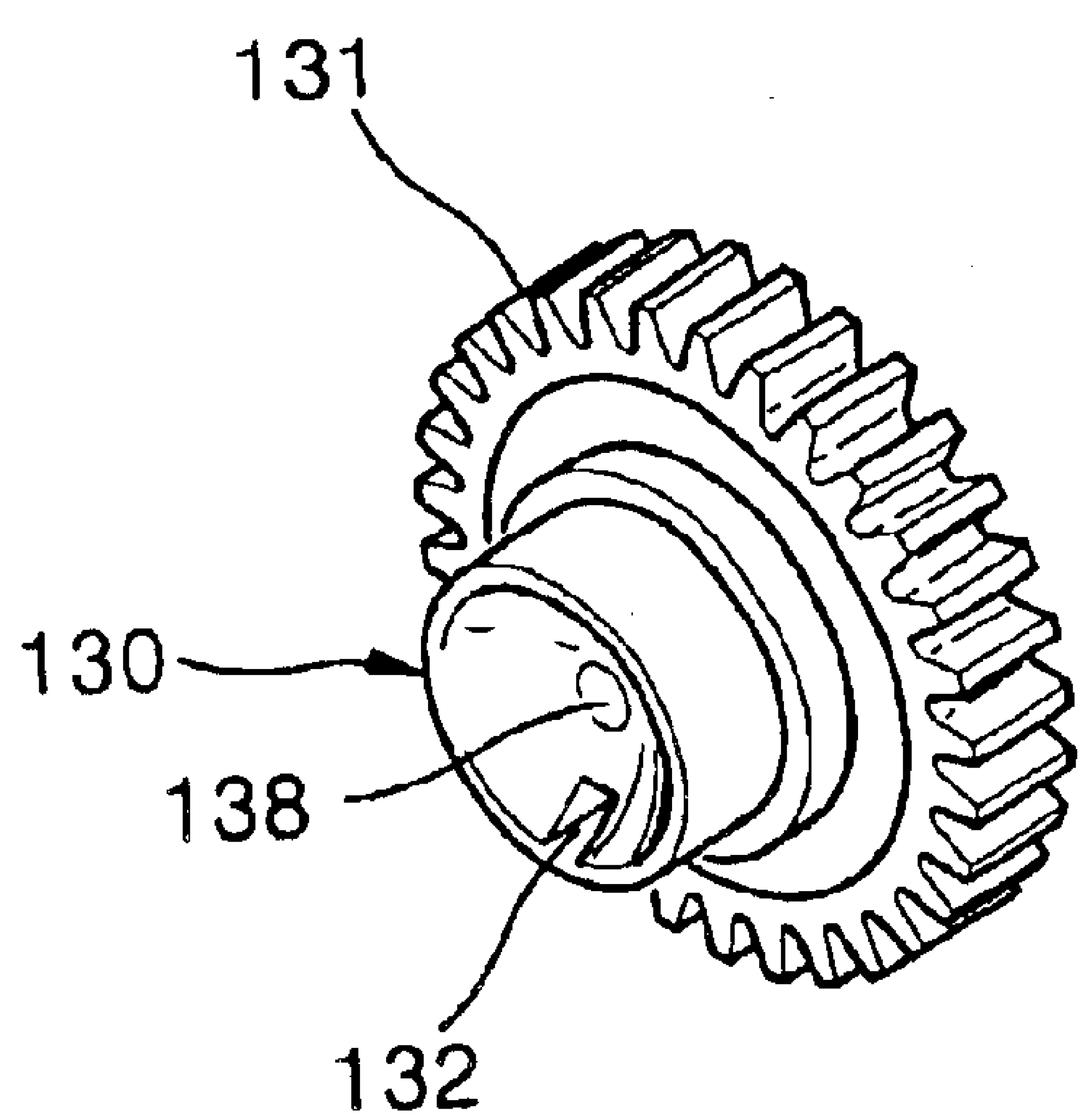
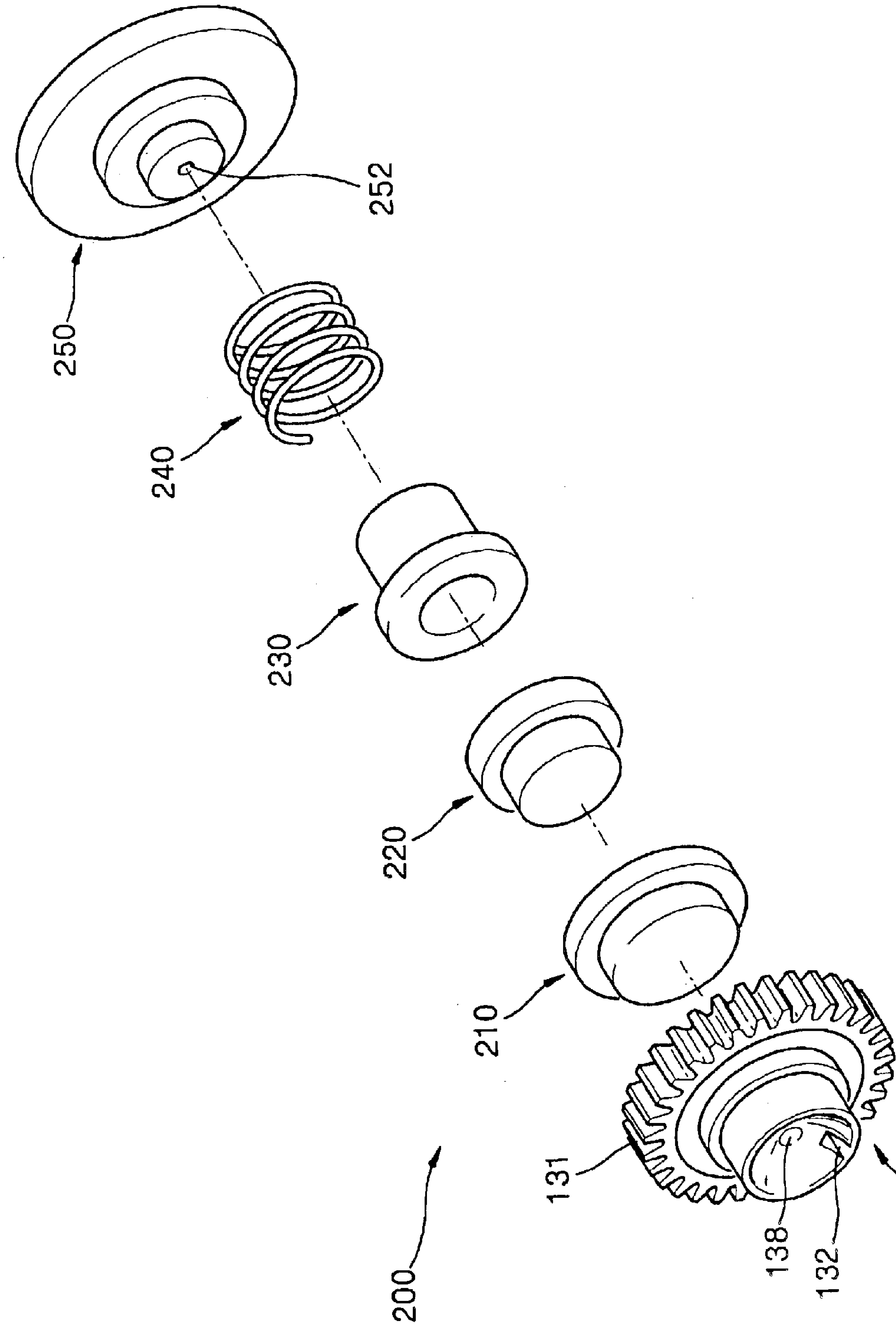


FIG. 7



FUSING DEVICE FOR AN ELECTROPHOTOGRAPHIC IMAGE FORMING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the priority of Korean Patent Application No. 2002-64545, filed on Oct. 22, 2002, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a fusing device for an electrophotographic image forming apparatus, and more particularly, to a fusing device for an electrophotographic image forming apparatus that uses heat generated when supercooled sodium acetate is crystallized, for an instant rising temperature of a fusing roller.

2. Description of the Related Art

In general, an electrophotographic printer includes a fusing device which heats the paper onto which a toner image is transferred, melts the toner image in a powder state on the paper, and fuses the melted toner image on the paper. The fusing device includes a fusing roller which fuses toner onto the paper, and a pressing roller which pushes the paper against the fusing roller.

FIG. **1** is a schematic profile cross-sectional view of a conventional fusing roller using a halogen lamp as a heat source, and FIG. **2** is a schematic frontal cross-sectional view of a conventional fusing device using the fusing roller of FIG. **1**. Referring to FIG. **1**, a fusing roller **10** includes a cylindrical roller **11** and a halogen lamp **12** installed inside the cylindrical roller **11**. A TEFLON® coating layer **11***a* is formed on a circumference of the cylindrical roller **11**. The cylindrical roller **11** is heated by radiant heat generated from the halogen lamp **12**.

Referring to FIG. **2**, a pressing roller **13** is placed under the fusing roller **10** to be opposite to the fusing roller **10**, and paper **14** is placed between the fusing roller **10** and the pressing roller **13**. The pressing roller **13** is elastically supported by a spring **13***a*. The pressing roller **13** closely adheres the paper **14**, which is passing between the fusing roller **10** and the pressing roller **13**, to the fusing roller **10** with a predetermined pressure. In this case, the toner image **14***a*, which is formed on the paper **14** in a powder state, is fused on the paper **14** due to the predetermined pressure and heat while passing between the fusing roller **10** and the pressing roller **13**.

A thermistor **15** and a thermostat **16** are installed at one side of the fusing roller **10**. The thermistor **15** measures a surface temperature of the fusing roller **10**, and the thermostat **16** cuts off power supplied to the halogen lamp **12** when the surface temperature of the fusing roller **10** exceeds a predetermined value. The thermistor **15** measures the surface temperature of the fusing roller **10** and transmits an electrical signal corresponding to the measured temperature to a controller (not shown) of a printer (not shown). The controller controls the power supplied to the halogen lamp **12** according to the measured temperature and maintains the surface temperature of the fusing roller **11** within a given range. When the temperature of the fusing roller **11** exceeds the predetermined set value because the controller fails in controlling the temperature of the fusing roller **11**, a contact (not shown) of the thermostat **16** becomes open to cut off the supply of power to the halogen lamp **12**.

Power consumption of a conventional fusing device using the halogen lamp **12** as a heat source is large. In particular, the conventional fusing device requires a fairly long warming-up time when power is supplied to the fusing device. Thus, a new fusing device having a short warming-up time is required.

SUMMARY OF THE INVENTION

The present invention provides a fusing device for an electrophotographic image forming apparatus that reduces a warming-up time by using melting heat of a supercooled working fluid during cold-start of the fusing device.

According to one aspect of the present invention, there is provided a fusing device for an electrophotographic image forming apparatus. The device includes a heat pipe, both ends of which are sealed and in which a predetermined amount of a supercooled working fluid capable of crystallizing and producing heat when acted on by a mechanical force is contained, a cylindrical roller which surrounds the heat pipe, and a heating element which is installed between the cylindrical roller and the heat pipe. At least one mechanical unit, which applies a mechanical force to the heat pipe and crystallizes the supercooled working fluid, is provided.

Also, the device may further include a cooling fan which supercools the working fluid.

Also, the mechanical unit may be a vibrator attached to one end side of the heat pipe.

Also, the vibrator may include a timer which operates the vibrator for several seconds only during cold-start.

Also, the vibrator may further include a motor, and the motor and the heating element may be connected in parallel to an external power supply.

Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and/or other aspects and advantages of the present invention will become more apparent by describing in detail preferred embodiments thereof with reference to the attached drawings in which:

FIG. **1** is a schematic profile cross-sectional view of a conventional fusing roller using a halogen lamp as a heat source;

FIG. **2** is a schematic frontal cross-sectional view of a conventional fusing device using the fusing roller of FIG. **1**.

FIG. **3** is a schematic frontal cross-sectional view of a fusing device for an electrophotographic image forming apparatus according to an embodiment of the present invention;

FIG. **4** is a cross-sectional view taken along line IV—IV of FIG. **3**;

FIGS. **5**A and **5**B are perspective views of a first end cap of FIG. **3**;

FIGS. **6**A and **6**B are perspective views of a second end cap of FIG. **3**; and

FIG. **7** is an exploded perspective view of a power connection unit of FIG. **3**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made in detail to the present preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below in order to explain the present invention by referring to the figures. Thicknesses of layers or regions shown in drawings are exaggerated for clarity of the specification.

FIG. **3** is a schematic frontal cross-sectional view of a fusing device for an electrophotographic image forming apparatus according to a first embodiment of the present invention, and FIG. **4** is a cross-sectional view taken along line IV—IV of FIG. **3**. Referring to FIGS. **3** and **4**, a fusing device **100** includes a fusing roller **110** having a cylindrical roller **112** which rotates in a direction in which a sheet of printer paper **150** having a toner image **151** thereon is ejected, i.e., in a direction indicated by an arrow A, and a pressing roller **160** which is installed to face the fusing roller **110** through the paper **150** therebetween and rotates in a direction indicated by an arrow B to be in a contact with the fusing roller **110**.

A toner protective layer **111** is formed of TEFLON® to a predetermined thickness, i.e., at a thickness of 20–30 μm, on the cylindrical roller **112**. A heater **113** is disposed on an inner surface of the cylindrical roller **112**, and a heat pipe **114**, both ends of which are sealed, is disposed on an inner surface of the heater **113**.

Meanwhile, a thermistor **118**, which measures a surface temperature of the fusing roller **110**, is installed on the toner protective layer **111**. Also, a thermostat **119** is installed at one side of the toner protective layer **111** and cuts off power supplied to the heater **113** and prevents overheating when the surface temperature of the fusing roller **110** is rapidly increased.

The heater **113** includes an Ni—Cr resistive coil **113***a* which generates heat by electricity supplied from an external power supply. Mica sheets **113***b* and **113***c*, which are insulating layers, are placed on and under the resistive coil **113***a*. The heater **113** includes a lead **117** which connects electricity to the resistive coil **113***a* formed on both ends of the heater **113**. A Cr—Fe coil may be used as the resistive coil **113***a* in one embodiment of the present invention.

The heat pipe **114** is formed in a tube shape, and both ends of the pipe are sealed. A predetermined amount of a working fluid **115** is contained in the heat pipe **114**. The working fluid **115** is a sodium acetate solvent and exists in a supercooled liquid state at a room temperature. In general, the sodium acetate solvent is used as a heat pack. The sodium acetate solvent is increased to a predetermined temperature, i.e., 54 C, when the sodium acetate is crystallized by an external shock. Also, if the temperature of the sodium acetate solvent exceeds 120 C due to heat generated in the heater **113**, water, which is mixed with the sodium acetate to form the sodium acetate solvent, is separated from the sodium acetate. The separated water, as well as water remaining in the sodium acetate solvent, is vaporized, and thus, the working fluid **115** serves as a thermal medium which transfers the heat to the cylindrical roller **112**, prevents a temperature deviation on the surface of the cylindrical roller **112**, and heats the overall cylindrical roller **112** within a short time.

If a sodium acetate solvent in which 10 g of sodium acetate mixed with 75 g of water is used as the working fluid **115**, and the sodium acetate solvent supercooled at a room temperature is stimulated, sodium acetate is crystallized, and the temperature of the sodium acetate solvent is increased to about 54 C. Here, if the percentage of sodium acetate in a sodium acetate solvent is increased, the temperature due to crystallization is increased, but the increase is very slight. Thus, preferably, the ratio of sodium acetate to water in the sodium acetate solvent is 100–150% by weight. The working fluid **115** takes a volume ratio of 5–70% with respect to the volume of the heat pipe **114**, preferably, 50–65%. A volume ratio of the working fluid **115** less than 5% is not preferable because a dry out is highly likely to occur.

Meanwhile, preferably, a cooling device, for example, a cooling fan (not shown), is provided at one side of the fusing roller **110**. When the image forming apparatus is off, the cooling fan may be used to supercool the sodium acetate solvent in the heat pipe **114**.

The heat pipe **114** is formed of copper (Cu), aluminum (Al), or aluminum alloy. The cylindrical roller **112** is heated by the heater **113** and by the vaporized heat generated from the working fluid **115** in the heat pipe **114**. The heat transferred to the cylindrical roller **12** then fuses the toner **151**, which is in a powder state formed on the paper **150**. The cylindrical roller **112** is formed of stainless steel, aluminum (Al), or copper (Cu)

A vibrator **140**, which is electrically driven, is attached to one end side of the heat pipe **114**. During a cold-start, an externally-controlled power is supplied to the vibrator **140**, and the vibrator **140** is driven by a timer for a predetermined amount of time. The vibrator **140** vibrates one end side of the heat pipe **114** to vibrate the sodium acetate solvent **115**, thereby solidifying the sodium acetate solvent **115**. Due to a heat generated in the solidifying process, the working fluid **115** is instantaneously increased to a predetermined temperature, for example, 54 C. Power connection to a motor of the vibrator **140** will be described later.

First and second end caps **120** and **130** are inserted in both ends of the cylindrical roller **112**. The structure of the second end cap **130** is substantially similar to the first end cap **120**, the significant difference being that a gear **131** is formed along an outer surface of the second end cap **130**. The gear on the outer surface of the second end cap **130** is engaged with a gear (not shown) of a motor (not shown), and is rotated by that motor's gear. Also, bearings **133** are installed at both ends of the fusing roller **110** to support the rotating fusing roller **110**.

FIGS. **5**A and **5**B are perspective views of a first end cap **120** of FIG. **3**, and FIGS. **6**A and **6**B are perspective views of a second end cap **130** of FIG. **3**. Referring to FIGS. **5**A through **6**B, lead holes **122** and **132**, through which a lead (**142** of FIG. **3**) is connected to both ends of the resistive coil **113***a*, and lead holes **128** and **138**, through which a lead (**142** of FIG. **3**) is connected to a motor (not shown) of the vibrator **140**, are formed in the first and second end caps **120** and **130**, respectively. One terminal of the motor of the vibrator **140** is connected to one end side of the heat pipe **114**, and is connected to external power through the lead **142** provided at the other end side of the heat pipe **114**. The other terminal of the motor of the vibrator **140** is connected to the external power through the lead **142**. Thus, the heater **113** and the motor of the vibrator **140** are connected in parallel to the external power, and a controlled power is supplied to the heater **113** and the motor of the vibrator **140**. Electrode grooves **126** and **136**, in which an electrode **210** is inserted, are formed at the center of the first and second end caps **120** and **130** opposite to the end of the heat pipe **114**. The electrode **210** supplies electricity to the leads **117** and **142** which pass through the lead holes **122**, **132**, **128**, and **138**, respectively.

FIG. **7** is an exploded perspective view of a power connection unit **200** connected to the second end cap **130**. Referring to FIG. **7**, the power connection unit **200** is installed in a frame (**170** of FIG. **3**) and transfers external power to the heater **113**. The power connection unit **200** includes an electrode **210** inserted in the electrode grooves **126** and **136**, a brush **220** which contacts the electrode **210**, and an elastic element **240** which closely adheres the brush **220** to the electrode **210** for an electrical contact. The brush **220** is connected to a lead (**254** of FIG. **3**) supplied from an external power supply and transfers electricity to the electrode **210**.

The elastic element **240** provides an elastic force to a spacer **230** so that the brush **220** is closely adhered to the electrode **210**. Even though thermal expansion or thermal contraction repeatedly occurs while the fusing roller **110** is operated, the elastic element **240** absorbs the resulting deformation to prevent the brush **220** from being isolated from the electrode **210**. Preferably, a compression spring is used as the elastic element **240**. In this embodiment, a lead (**254** of FIG. **3**) from the external power supply is connected to the brush **220** through a lead hole **252**. In this embodiment, the lead **254** and the elastic element **240** could make incidental contact, and sparks could occur. Thus, the spacer **230** is installed between the brush **220** and the elastic element **240**, in order to prevent a spark and also to prevent the end cap **130** from contacting the frame **170** due to the drawn-back brush **220**.

An end of the elastic element **240** is confined in the frame **170** by an insulating plate **250**. The insulating plate **250** supports the elastic element **240**. Thus, the brush **220** is first installed in a through hole formed in the frame **170**. Then the spacer **230** and the elastic element **240** are installed in the through hole. Next, the insulating plate **250** is installed so that the elastic element **240** is not drawn back.

The first and second end caps **120** and **130** may be made of a resin, such as polyphenylene sulfide (PPS), in which a filler material such as glass fiber, having small thermal deformation even at a high temperature, is inserted. Poly butylene terephthalate (PBT) and nylon are other possible preferred materials for the first and second end caps **120** and **130**.

The pressing roller **160** includes an elastic roller **161**, which contacts the fusing roller **110** and forms a fusing nip therebetween, and a shaft **162** which supports the elastic roller **161**. Bearings **163**, disposed at the circumference of the end of the shaft **162**, support the pressing roller **160**.

A process of manufacturing the fusing device **110** of an electrophotographic image forming apparatus having the above structure according to the present invention will be described below.

One end of a nearly cylindrical tube, which will be used as the heat pipe **114**, is sealed. An injection hole is formed at the other end of the cylindrical tube, through which a compression medium supplied from outside, i.e., a compressed liquid, is injected. In this case, it is preferable that deformation is reduced during the enlarging process at both ends of the cylindrical tube by forging both the ends in advance to remove a ductility and to planarize. Next, a circumference of the cylindrical tube **114** is wound by a mica sheet **113***c*. Then the resistive coil **113***a* is wound around the mica sheet **113***c*. Subsequently, the circumference of the cylindrical tub **114** wound by the resistive coil **113***a* is again wound by a mica sheet **113***b*. Next, the cylindrical tube **114** is inserted inside the cylindrical roller **112**, an outer surface of which is coated with TEFLON®. Subsequently, the compression medium is injected into the cylindrical tube **114** through the injection hole at the end of the cylindrical tube **114** under a predetermined pressure, i.e., 150 bars, and thereby the cylindrical tube **114** is enlarged. As a result, the cylindrical tube **114** and the heater **113** are closely adhered to the inside of the cylindrical roller **112**. Therefore, the cylindrical tube **114** is enlarged, and an air gap is not formed between the heater **113** and the cylindrical roller **112**, thus improving heat transfer efficiency.

The operation of the fusing device for an electrophotographic image forming apparatus having the above structure according to the present invention will be described in detail with reference to the accompanying drawings.

First, a cold start of the fusing device, in which the heat pipe filled with a predetermined volume of a sodium acetate solvent in a supercooled state at a room temperature is installed, will be described. If a controlled power is supplied from the external lead **254**, this power is connected to the lead **117** of the heater **113** and the lead **142** of the motor of the vibrator **140** through the brush **220** and the electrode **210**. Then, the vibrator **140** is driven by the timer for a predetermined amount of time and vibrates part of the sodium acetate solvent **115** in the heat pipe **114**. Due to this vibration, part of the sodium acetate starts to be crystallized and heated such that the temperature of the working fluid **115** is increased to 54 C. As a result, the heat pipe **114** is increased to a predetermined temperature. Heat is also generated at the resistive coil **113***a*. Most of the heat generated at the heater **113** is transferred to the cylindrical roller **112**. As such, the fusing roller **110** is rapidly increased to a target temperature, i.e., 180 C.

Subsequently, heat generated at the heater **113** is transferred to the heat pipe **114**. Due to this heat, the temperature of the heat pipe **114** is increased. If the temperature of the heat pipe **114** is increased over 120 C, the water which was mixed with the sodium acetate in the heat pipe **114** is heated and vaporized, and the heat formed by producing this steam is transferred to the cylindrical roller **112** through the heater **113** installed on the circumference of the heat pipe **114**. Heat generated at the heater **113** and heat generated at the working fluid **115** is transferred to the cylindrical roller **112** such that the fusing roller **110** is maintained at a predetermined temperature. In particular, a heat transfer rate of the steam in the heat pipe **114** is high. Thus, a temperature deviation on the surface of the fusing roller **110** can be greatly decreased, and printing quality of the fusing device **100** is improved.

Subsequently, in a printing mode, the toner **151** is transferred in a powder state onto the paper **150**, and the paper **150** passes between the fusing roller **110** and the pressing roller **160**, and the toner **151** is fused onto the paper **150** by the fusing roller **110** maintained at a predetermined temperature.

Meanwhile, as the fusing roller **110** fuses the paper **150**, the heat of the fusing roller **110** is taken to the paper **150**, and the steam inside the heat pipe **114** loses heat and is liquefied. Then, the working fluid **115**, to which heat is transferred by the heater **114**, is vaporized such that the surface temperature of the fusing roller **110** is maintained at a target temperature suitable for fusing the toner **151** onto the paper **150**. As such, the working fluid **115** in the heat pipe **114** serves as a thermal medium which repeatedly performs vaporization and liquefaction and maintains the fusing roller **110** at a predetermined temperature.

In general, a fusing temperature of a toner image is about 160–190 C. The fusing device **100** according to the present invention reaches the target temperature within about 12 seconds. The thermistor **118** measures the surface temperature of the fusing roller **110** and a controller (not shown) maintains the surface temperature of the fusing roller **110** within a predetermined range suitable for fusing the toner **151** onto the paper **150**. If adjustment of the surface temperature fails and the surface temperature of the fusing roller **110** rapidly increases, the thermostat **119** cuts off the power connection unit **200** connected to the thermostat **119** through a mechanical operation and prevents a rapid increase in the surface temperature of the fusing roller **110**. This power supply operation may be varied according to a set temperature, and may be performed using various controlling methods such as periodic on/off, pulse width modulation (PWM), or proportional and integral (PI).

Meanwhile, if an electrophotographic image forming apparatus having a fusing device according to the present invention is entered into a long-term standstill state, and the fusing device **100** stops, the cooling fan at one side of the image forming apparatus is operated such that the working fluid, including sodium acetate, is supercooled, and the supercooled sodium acetate solvent is again formed in the heat pipe **114**.

As described above, in the fusing device for an electrophotographic image forming apparatus according to the present invention, during a cold-start, a warming-up time can be reduced using a melting heat of a supercooled sodium acetate solvent, and in a printing mode, the surface temperature of a fusing roller can be uniformly maintained using a thermal medium in the heat pipe.

Although a few preferred embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in this embodiment without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. A fusing device for an electrophotographic image forming apparatus, the device comprising:

a heating pipe, both ends of which are sealed and in which a predetermined amount of a working fluid is contained, wherein the working fluid is supercooled at room temperature, and crystallizing and producing heat when acted on by a mechanical force;

a cylindrical roller which surrounds the heat pipe;

a heating element which is installed between the cylindrical roller and the heating pipe;

at least one mechanical unit which applies the mechanical force to the heating pipe and crystallizes the supercooled working fluid; and

a pressing roller which closely adheres to the fusing roller.

2. The device of claim **1**, wherein the working fluid is a sodium acetate solvent.

3. The device of claim **2**, wherein the sodium acetate solvent has a volume ratio of 50–65% with respect to the volume of the heating pipe.

4. The device of claim **2**, wherein the ratio of sodium acetate to water in the sodium acetate solvent is 100–150% by weight.

5. The device of claim **1**, further comprising a cooling fan which supercools the working fluid.

6. The device of claim **1**, wherein the mechanical unit is attached to one end side of the heating pipe.

7. The device of claim **6**, wherein the mechanical unit is a vibrator.

8. The device of claim **7**, wherein the vibrator includes a timer which operates the vibrator for several seconds only during cold-start.

9. The device of claim **7**, wherein the vibrator includes a motor, and the motor and the heating element are connected in parallel to an external power supply.

10. The device of claim **9**, wherein one terminal of the motor is connected to one end side of the heat pipe, and the remaining side of the heat pipe and the remaining terminal of the motor are each connected to the external power supply.

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